WEST Search History

DATE: Wednesday, September 17, 2003

Set Name side by side	**Query**	**Hit Count**	**Set Name** result set
	DB=USPT,JPAB,EPAB,DWPI,TDBD; PLUR=YES; OP=OR		
L11	L10 and l7	9	L11
L10	((pre adj cod$3) or (precod$3))	2469	L10
L9	((pre adj cod$3) or (precod$3)) and (match$3 near2 filter$) and (gaussian$ near2 filter$)	5	L9
L8	((pre adj cod$3) or (precod$3)) and (match$3 near2 filter$) same (gaussian$ near2 filter$)	1	L8
L7	L5	1217	L7
L6	L5	1217	L6
L5	(375/274.ccls. or 375/272.ccls. or 375/303.ccls. or 375/305.ccls. or 375/334.ccls. or 375/336.ccls.)	1217	L5
L4	((continuous$ near2 phase near2 modulat$3) or (minimum near shift near key$3) or (GMSK)) and ((pre adj cod$3) or (precod$3)) and (match$3 near2 filter$) and (gaussian$ near2 filter$)	2	L4
L3	((continuous$ near2 phase near2 modulat$3) or (minimum near shift near key$3) or (GMSK)) and (precod$3) and (match$3 near2 filter$) and (gaussian$ near2 filter$)	1	L3
L2	((continuous$ near2 phase near2 modulat$3) or (minimum near shift near key$3)) and (precod$3) and (match$3 near2 filter$) and (gaussian$ near2 filter$)	1	L2
L1	((continuous$ near2 phase near2 modulat$3) or (minimum near shift near key$3)) same (precod$3) same (match$3 near2 filter$) same (gaussian$ near2 filter$)	0	L1

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L1: Entry 12 of 13 File: EPAB Sep 12, 1990

DOCUMENT-IDENTIFIER: EP 386412 A1
TITLE: GMSK modulator.

Abstract Text (1):
CHG DATE=19990617 STATUS=O> The invention relates to an arrangement for modulation of a digital message according to the GMSK method (Gaussian Minimum Shift Keying) which displays behaviour similar to that of a single-sideband modulator due to appropriate pre-processing (pre-coding). A device of a simple type is to be produced for the generation of a GMSK signal. For this purpose, the invention provides for a selection of the intermediate frequency of the generated single-sideband spectrum (modulator output frequency) such that the condition f(ZF) = ft/4 + n . ft/2 for n >/= 1 is satisfied, in which the system has a clearly defined pulse response. The system is implemented by means of a transversal filter and the entire arrangement in a PROM.

WEST Search History

DATE: Monday, September 22, 2003

Set Name side by side	Query	Hit Count	Set Name result set
	DB=USPT,JPAB,EPAB,DWPI,TDBD; PLUR=YES; OP=OR		
L3	((continous$ near phase near2 modulat$3) or (gmsk)) and ((pre adj cod$3) or (precod$3))	19	L3
L2	((continous$ near phase near2 modulat$3) or (gmsk)) and ((pre adj cod$3) or (precod$3)) and (gaussian near2 filter$)	5	L2
L1	((continous$ near phase near2 modulat$3) or (gmsk)) same ((pre adj cod$3) or (precod$3))	13	L1

END OF SEARCH HISTORY

L2: Entry 15 of 35 File: USPT Oct 17, 2000

DOCUMENT-IDENTIFIER: US 6134427 A
TITLE: Using a single low-noise amplifier in a multi-band wireless station

Abstract Text (1):
A wireless communication device, such as a dual-mode cellular phone, receives radio frequency (RF) signals in either of two communication bands. Each received RF signal is passed to two bandpass filters, one for each communication band, the outputs of which are connected to a single amplifier. The amplifier processes the received signal regardless of the communication band in which the signal was received. The amplifier can include two sets of similar circuitry, e.g., matching circuits, one for each communication band, which are selected alternatively to process received signals in the corresponding communication band.

Brief Summary Text (4):
In a multi-band wireless communication network, wireless stations communicate by sending signals to each other in multiple, preassigned communication frequency bands. Each station in the network must be able to receive and process signals in each of these frequency bands. For example, in a GSM/DCS dual-mode system, each station must process radio frequency (RF) signals in both the Global System for Mobile (GSM) and the Digital Communication Service (DCS) bands. In general, much of the circuitry in a multi-mode wireless station is replicated once for each communication band in which the station must communicate.

Brief Summary Text (5):
FIG. 1 is a simplified schematic diagram of a typical GSM/DCS dual-mode wireless phone 10. The phone 10 includes a transmitter 12 and a receiver 14 that send and receive signals, respectively, through a wireless network via an antenna 16 and an antenna interface circuit 18. The receiver 14 includes two front-end filtering circuits coupled to the antenna interface circuit 18: a GSM circuit, which processes only those signals transmitted in the GSM band; and a DCS circuit, which processes only those signals transmitted in the DCS band. The GSM and DCS front-end receiver circuits are virtually identical in structure, with the GSM circuit including a GSM-band surface acoustic wave (SAW) filter 20, a low-noise amplifier 22, and a GSM-band image-reject filter 24 arranged in series; and with the DCS circuit including a DCS-band SAW filter 26, a low-noise amplifier 28, and DCS-band image reject filter 30 arranged in series. The image reject filters 24, 30 remove unwanted shadow, or "image," signals received at frequencies other than the GSM and DCS carrier frequencies. A switch 32 applies the output signal from one of the front-end receiver circuits, via a power amplifier 34, to a double side band (DSB) mixer 36. The double side band mixer 36 mixes the signal from the front-end receiver circuits with an amplified signal from a voltage controlled oscillator (VCO) 38 and delivers the resulting intermediate frequency (IF) signals to subsequent circuitry for processing and demodulation.

Brief Summary Text (6):
FIG. 2 shows a typical structure for both the GSM-band and the DCS-band low-noise amplifiers 22, 28 (FIG. 1). Each amplifier includes a transistor-based linear amplifier 40 coupled to two matching circuits: an input matching circuit 42 that receives a GSM-band or DCS-band signal from one of the SAW filters 20, 26 (FIG. 1) and provides the signal as input to the linear amplifier 40; and an output matching circuit 44 that receives the amplified signal from the linear amplifier 40 and delivers it to one of the image reject filters 24, 30 (FIG. 1). Because a conventional multi-mode wireless phone includes a low-noise amplifier for each communication band, the conventional phone includes multiple copies of each of the components shown in FIG. 2.

Brief Summary Text (8):
The invention was developed, in part, to provide a common signal processing path for all signals received by a multi-band wireless station and to reduce the number of components required in the signal processing circuitry. The invention features the reception of radio frequency (RF) signals in either of two communication bands in a wireless communication system, such as a dual-mode cellular phone. Each received RF signal is passed to two bandpass filters, one for each communication band, the outputs of which are connected to a single amplifier, which amplifies the signal regardless of the communication band in which the signal was received.

Drawing Description Text (3):
FIG. 1 is a schematic diagram of a conventional dual-mode wireless station.

Drawing Description Text (4):
FIG. 2 is a schematic diagram of a low-noise amplifier used in the conventional dual-mode station of FIG. 1.

Drawing Description Text (5):
FIG. 3 is a schematic diagram of a dual-mode wireless station having a single low-noise amplifier for use in processing signals in both communication bands.

Detailed Description Text (3):
FIG. 3 is a simplified schematic diagram of a GSM/DCS dual-mode wireless station 50 having a single low-noise amplifier 56 for use in processing signals in both the GSM and DCS communication bands. Unlike the wireless station shown in FIG. 1, this wireless station 50 does not include separate low-noise amplifiers for the GSM and DCS communication bands. Moreover, the wireless station may include a single side band (SSB) image reject mixer 62 instead of a dual side band mixer, which eliminates the need for image reject mixers in the signal processing path. Use of a SSB image reject mixer is described in U.S. patent application 09/163,712 filed on Sep. 30, 1998, by Simon A. Hughes, John R. Rowland, Jr.,and Emmanuel Ngompe and entitled "Using a Single Side Band Mixer to Reject Image Signals In a Wireless Station," which is incorporated by reference.

Detailed Description Text (4):
The mobile station includes a GSM-band filter 54 and a DCS-band filter 58, both of which may be surface acoustic wave (SAW) filters, which receive incoming signals from an antenna 64 via an antenna interface 66. The bandwidth of the GSM-band filter 54 is approximately 935 to 960 MHZ, and the bandwidth of the DCS-band filter 58 is approximately 1805 MHZ to 1880 MHZ.

Detailed Description Text (5):
The GSM-band and DCS-band filters 54, 58 both connect to the low-noise amplifier circuit 56, which amplifies the incoming signals and provides them to the SSB mixer 62. A controller 60 provides a control signal to the low-noise amplifier circuit 56 to configure the amplifier 60 for operation in the appropriate communication band, as described below. The mobile station 50 also may include a high pass filter circuit before the DCS-band filter 58, as described in the U.S. application incorporated by reference above.

Detailed Description Text (6):
FIG. 4 shows the structure of the low-noise linear amplifier 56. The amplifier includes a transistor-based linear amplifier 70 coupled to a variable input matching circuit 72 and a variable output matching circuit 74. The input matching circuit 72 is an L-C circuit that includes two inductors L1, L2 arranged in parallel and two capacitors C1, C2 arranged in parallel. A diode D1 is connected in series with one of the inductors L2, and another diode D2 is connected in series with one of the capacitors C2. The diodes D1, D2 serve to vary the resonant frequency of the input matching circuit 72 by selectively removing the series-connected inductor L2 and capacitor C2 from the circuit, under the control of a signal CTRL generated by the controller 60 (FIG. 3). In particular, the diodes D1, D2 do not conduct, and therefore the inductor L2 and the capacitor C2 are removed from the input matching circuit 72, when the controller holds the control signal CTRL to a low value. In this situation, one inductor L1 and one capacitor C1 are used to provide the

resonant frequency that is appropriate for communication in one of the frequency bands, e.g., the GSM band. When the mobile station 50 must communicate in the other communication band, e.g., the DCS band, the controller asserts the control signal CTRL, which causes the diodes D1, D2 to conduct and therefore varies the resonant frequency of the input matching circuit 72.

Detailed Description Text (8):
A number of embodiments of the present invention have been described. Neverthe-less, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, while the invention has been described in terms of a dual-mode wireless station, the invention is suitable for communication in any number of frequency bands. Also, switching devices other than diodes may be used to configure the low-noise amplifier for operation in the various bands. Accordingly, other embodiments are within the scope of the following claims.

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L2: Entry 10 of 35 File: USPT May 28, 2002

DOCUMENT-IDENTIFIER: US 6397068 B1
TITLE: System and method for optimally selecting guard bands in a dual mode network

Abstract Text (1):
A system identifies analog channels for reclamation in a dual mode system (100) having a digital network (110) overlaid on an analog network (120). The digital network (110) includes multiple digital cell sites. The analog network (120) includes multiple analog cell sites. The system measures an amount of interference caused by the analog cell sites and an amount of interference caused to the digital cell sites. The system then compares the interference amounts to one or more thresholds and determines for which of the analog channels the interference amounts exceed the thresholds. The system selects the determined analog channels for reclamation.

Brief Summary Text (3):
The present invention relates generally to wireless communications systems and, more particularly, to a system and method for optimally selecting guard bands in a dual mode network, such as a Code Division Multiple Access (CDMA) system overlaid on an existing Advanced Mobile Phone System (AMPS).

Brief Summary Text (5):
AMPS is an analog system that permits communication by mobile units operating within an analog cell site. CDMA systems, on the other hand, are digital systems that permit communication by portable units operating within a CDMA footprint; i.e., a geographical area offering digital CDMA service. In a dual mode network, the CDMA system is overlaid on an analog AMPS.

Brief Summary Text (6):
Because both the AMPS and CDMA system operate concurrently in the dual mode network, some interference inherently occurs. Generally, there are four possible interference mechanisms between the AMPS and the CDMA system both operating in the 800-900 MHz frequency band (i.e., base station transmit frequency in the range of 869-894 MHz and receive frequency in the range of 824-849 MHz): (1) interference from AMPS sites to CDMA portable units; (2) interference from AMPS mobile units to CDMA sites; (3) interference from CDMA portable units to AMPS sites; and (4) interference from CDMA sites to AMPS mobile units.

Brief Summary Text (8):
If the AMPS site does not cause excessive interference to any CDMA portable unit due to a very high path loss, for example, the path loss from a mobile unit within the AMPS site's serving area may still cause interference to the CDMA system if the path loss between the AMPS mobile unit and the CDMA base station is very low. This may occur when an AMPS mobile unit transmits over water, from elevated highways or mountain roads, etc.

Brief Summary Text (14):
In accordance with the purpose of the invention as embodied and broadly described herein, a system consistent with the present invention identifies analog guard band channels for reclamation in a dual mode system having a digital network overlaid on an analog network. The digital network includes multiple digital cell sites. The analog network includes multiple analog cell sites. The system measures an amount of interference caused by the analog cell sites and an amount of interference caused to the digital cell sites. The system then compares the interference amounts to one or more thresholds and determines for which of the analog channels the interference amounts exceed the thresholds. The system selects the determined analog channels for

reclamation.

Brief Summary Text (15):
In another implementation consistent with the present invention, a computer program product, stored on at least one memory device, identifies analog channels for reclamation in a dual mode system having a digital network overlaid on an analog network. The digital network include multiple digital sites, and the analog network includes multiple analog sites. The computer program product includes a forward link analysis module and a reverse link analysis module.

Brief Summary Text (16):
The forward link analysis module determines the first amount of interference caused by the analog sites to portable units operating in the digital sites, compares the first interference amount to a first threshold, and identifies analog channels for reclamation based on a result of the comparison. The reverse link analysis module determines the second amount of interference caused by mobile units operating in the analog sites to the digital sites, compares the second interference amount to a second threshold, and identifies analog channels for reclamation based on a result of the comparison.

Drawing Description Text (3):
FIG. 1 is a diagram of a dual mode network in which systems and methods consistent with the present invention may be implemented;

Drawing Description Text (9):
FIGS. 7A and 7B are flowcharts of processing for identifying guard band channels that may be reclaimed based on interference caused by AMPS mobile units to CDMA sites in an implementation consistent with the present invention;

Drawing Description Text (11):
FIG. 9 is an exemplary graph illustrating guard zone threshold for AMPS mobile unit interference at the CDMA site's location versus the site's available receive filter rejection.

Detailed Description Text (3):
Systems and methods consistent with the present invention identify guard band channels that may be reclaimed for use by the AMPS in a dual mode network, where the CDMA system is overlaid on the AMPS. In some instances, it may be possible to reclaim one or more of the guard band channels while preserving channel quality and minimizing interference.

Detailed Description Text (6):
FIG. 1 is a diagram of an exemplary dual mode network 100 in which systems and methods consistent with the present invention may be implemented. The network 100 includes a CDMA system (i.e., footprint) 110 overlaid on an AMPS 120. In the figure, dual mode cell sites (i.e., cell sites having CDMA overlaid on AMPS) are designated by squares and AMPS-only cell sites are designated by ovals.

Detailed Description Text (7):
The detailed description refers to mobile units as operating within the AMPS 120 and portable units as operating within the CDMA system 110. Typically, mobile units can transmit at a higher power than portable units. The following detailed description applies equally to portable units operating within the AMPS 120, mobile units operating within the CDMA system 110, and to stationary units that are not truly portable or mobile.

Detailed Description Text (13):
As will be described in detail below, a device 200, consistent with the present invention, optimally selects guard bands that require clearing in a dual mode network. The device 200 performs this task in response to the processor 210 executing sequences of instructions contained in, for example, memory 220. The instructions may be read into memory 220 from another computer-readable medium, such as the storage device 240, or from another device via the communication interface 290.

Detailed Description Text (16):
The dual mode network 100 (FIG. 1) includes a digital CDMA cellular system 110 (or footprint) overlaid on an analog AMPS 120. Each system 110 and 120 operates concurrently. An interference module analyzes interference between the two systems and determines the number of AMPS channels (i.e., guard band channels) that may be reclaimed at any analog site lying in the guard zone. In other words, the module identifies those of the 9 AMPS channels cleared by conventional systems that may be reclaimed and used by the AMPS 120. The interference analyzing module may include a computer, such as the device 200, that contains information on both the CDMA and AMPS networks, such as coverage, traffic, etc.

Detailed Description Text (17):
Generally, the interference analysis module consistent with the present invention uses a defined CDMA coverage area in conjunction with the CDMA traffic pattern to create a CDMA footprint for interference analysis. Based on the interference mechanism being analyzed, the interference power is computed at the mobile/portable unit's or site's location and then compared to a threshold that includes the transmitter and receiver filter protection and system loading characteristics. The threshold is a value or level consistent with a desired service quality objective. If the interference power exceeds this threshold, then the AMPS site is determined to be lying in the guard zone and the amount of spectrum that needs to be cleared at this site is calculated.

Detailed Description Text (18):
The guard zone analysis studies four kinds of mutual interference possible between the AMPS and the CDMA systems, including the interference from AMPS sites to CDMA portable units, the interference from AMPS mobile units to CDMA sites, the interference from CDMA portable units to AMPS sites, and the interference from CDMA sites to AMPS mobile units. The dominant sources of interference for identifying guard band channels for reclamation include interference from AMPS sites to CDMA portable units (i.e., forward link interference) and interference from AMPS mobile units to CDMA sites (i.e., reverse link interference).

Detailed Description Text (21):
In addition to creating the CDMA footprint, the device 200 assigns traffic (Erlangs/sector) to the AMPS sites [step 305]. The AMPS traffic assignment may be used to determine whether a mobile unit exists at a certain location, and might be arbitrarily set by the device 200 or user-defined.

Detailed Description Text (26):
The device 200 then analyzes the CDMA portable unit's receive filter response to determine the filter rejection for each of the guard band channels 1 through 9 [step 330] (FIG. 3B). For this analysis, the device 200 may determine whether the portable unit's receive filter response meets the receive filter mask required by the IS-95A/B standards.

Detailed Description Text (34):
The CDMA portable units close to the dual mode site encounter very high interference from the co-located AMPS site. These portable units have a high forward link margin, however, and, thus, can tolerate higher values of AMPS interference. For example, as shown in FIG. 5, if the forward link margin in the core areas of the network is always greater than 15 dB, then reclaiming channel 9 means that the AMPS interference needs to be higher than -55 dBm to cause a problem. In practice, received power may be down to -60 dBm within 100 meters from the AMPS site. Of course, this would differ from region to region, but typically within 100 meters, the CDMA portable units are likely to have a higher value (higher than 15 dB) of forward link margin.

Detailed Description Text (36):
Accordingly, guard band channels may be reclaimed even at the dual mode, co-located AMPS sites (i.e., inside the CDMA footprint). The reclamation is a function of the forward link margins available in the serving area of that co-located CDMA sector, the AMPS site's ERP (and all related propagation phenomena), and the CDMA portable unit's filter rejection available in that guard band.

Detailed Description Text (37):
The device 200 reports the size of the guard band (in terms of guard band channels) at the cleared AMPS site that may be reclaimed [step 350] and returns to step 310 (FIG. 3A) to determine whether all of the AMPS sites have been analyzed for interference. If all of the AMPS sites have been analyzed, the device 200 begins analysis for determining whether any guard band channels may be reclaimed based on interference caused by AMPS mobile units to CDMA sites.

Detailed Description Text (38):
FIGS. 7A and 7B are flowcharts of processing for identifying guard band channels that may be reclaimed based on interference caused by AMPS mobile units to CDMA sites in an implementation consistent with the present invention. Processing begins with the device 200 determining whether all of the AMPS mobile units in the network have been analyzed for interference [step 705] (FIG. 7A).

Detailed Description Text (39):
If some of the AMPS mobile units have not been analyzed for interference, the device 200 performs analysis for each AMPS mobile unit in the network [step 710]. The device 200 begins the analysis by calculating for a selected AMPS mobile unit, the interference power from the mobile unit received at every CDMA site [step 715]. For a CDMA site under consideration, the device 200 calculates the guard zone threshold based on the CDMA site's thermal noise floor and any rise above the thermal noise floor due to multi-user traffic [step 720]. In this case, the guard zone threshold is defined as the maximum AMPS interference power that can be tolerated by a CDMA site at a specific location in the network. In general, the higher the guard zone threshold, the stronger the tolerance is to AMPS interference.

Detailed Description Text (42):
The device 200 analyzes the CDMA site's receive filter response to determine the filter rejection for each of the guard band channels 1 through 9 [step 725]. For this analysis, the device 200 may determine whether the site's receive filter response meets the receive filter mask required by the IS-95A/B standards. FIG. 8 is a graph of a CDMA site's receive filter mask, as required by the IS-95A/B standards. The graph shows that the CDMA site's receive filter response has two breakpoints at approximately 750 kHz and 900 kHz.

Detailed Description Text (43):
The device 200 then determines whether the AMPS mobile unit causes interference to a CDMA site by determining whether the interference power from the AMPS mobile unit is greater than or equal to the combination of the guard zone threshold and the filter rejection for any of the guard band channels 1 through 9 [step 730] (FIG. 7B). This determination may be expressed as follows:

Detailed Description Text (44):
where I.sub.AMPS is the interference power received from the AMPS mobile unit at the site location; T.sub.GZ.sub..sub.-- .sub.CDMA.sub..sub.-- .sub.S is the guard zone threshold from (3) above; and F.sub.CDMA.sub..sub.-- .sub.S.sub..sub.-- .sub.RF (f) is the CDMA site's receive filter rejection (FIG. 8). As in expression (2), the 6 dB decrease ensures that the resulting elevation in the noise floor of the CDMA site due to the AMPS mobile unit interference is set to a tolerable level.

Detailed Description Text (45):
If the interference power from the AMPS mobile unit is not greater than or equal to the combination of the guard zone threshold and the filter rejection for any of the guard band channels, processing returns to step 705 (FIG. 7A), where the device 200 determines whether all of the AMPS mobile units have been analyzed for interference. If the interference power is greater, however, the device 200 reports the serving AMPS site for this AMPS mobile unit for spectrum clearing [step 735]. After reporting the AMPS site for spectrum clearing, the device 200 may determine in how many guard band channels the AMPS mobile unit's interference power is greater than or equal to the combination of the guard zone threshold and the filter rejection [step 740]. These guard bands may then be reclaimed.

Detailed Description Text (46):
FIG. 9 is an exemplary graph illustrating guard zone threshold for AMPS mobile unit

interference at the CDMA site's location versus the site's available receive filter rejection. As the graph illustrates, the guard zone threshold increases with the available CDMA site's receive filter rejection in the guard bands. For a minimum mask requirement of 37 dB protection in the guard band channels 6 to 9, for example, the guard zone threshold is -73 dBm for 50% system loading and -70 dBm for 75% system loading. For a typical filter rejection of 50 dB, the thresholds reduce to -60 dBm and -57 dBm, respectively, depending on the CDMA system loading. Even the mask level of filter rejection offers a threshold of -73 dBm, which may be acceptable for satisfactory operation without substantial interference. For most environments, the receiver sensitivity level for an AMPS mobile unit is set around -75 dBm and, hence, power control would ensure that the AMPS mobile units have a low transmit power at locations close to the CDMA site.

Detailed Description Text (47):
Accordingly, the guard band channels may be reclaimed even at the dual mode, co-located AMPS sites (i.e., those sites inside the CDMA footprint). The guard band channel reclamation is a function of the AMPS mobile unit's transmit power (especially at locations close to the co-located CDMA site), the CDMA system loading, and the CDMA site's filter rejection available in that guard band.

Detailed Description Text (48):
The device 200 reports the size of the guard band (in terms of guard band channels) at the cleared AMPS site that may be reclaimed [step 745] and returns to step 705 (FIG. 7A) to determine whether all of the AMPS mobile units have been analyzed for interference. If all of the mobile units have been analyzed, processing ends. The device 200 may then generate a guard zone report listing all of the AMPS sites where the frequency spectrum needs to be cleared, the number of AMPS channels to be cleared in these sites, and the number of AMPS channels that may be reclaimed in these sites. This report might include the AMPS sites' names with their corresponding sector numbers, their type (AMPS only or dual mode), the AMPS channel numbers that need to be cleared, and the AMPS channel numbers that may be reclaimed.

Detailed Description Text (50):
Systems and methods consistent with the present invention facilitate the reclamation of guard band channels in dual mode networks. Based on the forward link interference analysis from the AMPS sites to the CDMA portable units, particular guard band channels may be reclaimed under certain conditions. Such reclamation is a function of the portable unit forward link margins available in the serving area of that co-located CDMA sector, the AMPS site's ERP (and all related propagation phenomena) and the portable unit's filter rejection available in these guard bands.

Detailed Description Text (51):
Based on the reverse link interference analysis from the AMPS mobile units to the CDMA sites, particular guard band channels may be reclaimed under certain conditions. This reclamation is a function of the AMPS mobile unit's transmit power (or the efficiency of the power control especially at locations close to the co-located CDMA site), the CDMA system W loading, and the CDMA site's filter rejection available in these guard bands.

Other Reference Publication (7):
Sivarajan, Kumar N. et al., Channel Assignment in Cellular Radio, CH2379-1/89/0000/0846, IEEE, 1989, p. 846-850.

Other Reference Publication (9):
Recommended Minimum Standards for 800-MHZ Cellular Subscriber Units, EIA/IS-19-B, May 1998.

Other Reference Publication (10):
Recommended Minimum Standards for 800-MHZ Cellular Land Stations, EIA/IS-20-A, May 1988.

Other Reference Publication (11):
Recommended Minimum Performance Standards for Base Stations Supporting Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations, PN-3645 (TIA/EIA/IS-97-A), Ballot

Version, Feb. 26, 1996.

Other Reference Publication (12):
Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectgrum Cellular Mobile Stations, TIA/EIA/IS-98-A, Published Version, Apr. 17, 1996.

CLAIMS:

1. A method for identifying analog channels for reclamation in a dual mode system having a digital network overlaid on an analog network, the digital network including a plurality of digital cell sites, and the analog network including a plurality of analog cell sites, the method comprising:

measuring an amount of interference caused by the analog cell sites;

measuring an amount of interference caused to the digital cell sites;

individually comparing the interference amounts to one or more thresholds;

determining for which of a plurality of analog channels the interference amounts exceed the one or more thresholds; and

selecting the determined analog channels for reclamation.

8. The method of claim 1, wherein the digital cell sites interference measuring includes:

identifying an amount of interference power from each of a plurality of mobile units operating in the analog cell sites that is received at each of the digital cell sites.

9. The method of claim 1, wherein the digital cell sites interference measuring includes:

ascertaining a maximum interference from mobile units operating in the analog cell sites that can be tolerated by each of the digital cell sites.

14. A system for identifying analog channels for reclamation in a dual mode system having a digital network overlaid on an analog network, the digital network including a plurality of digital cell sites, and the analog network including a plurality of analog cell sites, the system comprising:

means for measuring an amount of interference caused by the analog cell sites;

means for measuring an amount of interference caused to the digital cell sites;

means for comparing the interference amounts to one or more thresholds;

means for determining for which of a plurality of analog channels the interference amounts exceed the one or more thresholds; and

means for selecting the determined analog channels for reclamation.

15. A system for identifying analog channels for reclamation in a dual mode system having a digital network overlaid on an analog network, the digital network including a plurality of digital sites, and the analog network including a plurality of analog sites, the system comprising:

a memory configured to store instructions; and

a processor configured to execute the instructions in the memory to measure a first amount of interference caused by the analog sites, measure a second amount of interference caused to the digital sites, compare the first interference amount to a first threshold, compare the second interference amount to a second threshold, determine for which of a plurality of analog channels the first and second

interference amounts respectively exceed the first and second thresholds, and select the determined analog channels for reclamation.

22. The system of claim 15, wherein the processor is configured to identify an amount of interference power from each of a plurality of mobile units operating in the analog sites that is received at each of the digital sites to measure the second interference amount.

23. The system of claim 15, wherein the processor is configured to ascertain a maximum interference from mobile units operating in the analog sites that can be tolerated by each of the digital sites to measure the second interference amount.

28. A computer-readable medium containing instructions for causing at least one processor to perform a method for identifying analog channels for reclamation in a dual mode system having a digital network overlaid on an analog network, the digital network including a plurality of digital sites, and the analog network including a plurality of analog sites, the method comprising:

measuring an amount of interference caused by the analog sites to portable units operating in the digital sites;

measuring an amount of interference caused to the digital sites by mobile units operating in the analog sites;

individually comparing the interference amounts to one or more thresholds;

determining for which of a plurality of analog channels the interference amounts exceed the one or more thresholds; and

selecting the determined analog channels for reclamation.

29. A computer program product, stored on at least one memory device, for identifying analog channels for reclamation in a dual mode system having a digital network overlaid on an analog network, the digital network including a plurality of digital sites, and the analog network including a plurality of analog sites, the computer program product comprising:

a forward link analysis module configured to determine a first amount of interference caused by the analog sites to portable units operating in the digital sites, compare the first interference amount to a first threshold, and identify analog channels for reclamation based on a result of the comparison; and

a reverse link analysis module configured to determine a second amount of interference caused by mobile units operating in the analog sites to the digital sites, compare the second interference amount to a second threshold, and identify analog channels for reclamation based on a result of the comparison.

L4: Entry 1 of 2 File: USPT Aug 6, 2002

DOCUMENT-IDENTIFIER: US 6430212 B1
TITLE: Spread-spectrum GMSK/M-ary radio

Brief Summary Text (6):
With respect to FDMA, as the number of networks increases within a given geophysical area, the degree of separation achieved with the FDMA scheme is reduced. This results in one network interfering with the networks that use adjacent frequency signals. This interference is most detrimental when a radio causing the interference is closer to a base station than a mobile radio that actually belongs to the base station's network. This phenomenon is called the "near-far" interference problem. This problem is somewhat mitigated by confining the frequency spectrum of the communication signals for each network. Gaussian-filtered, Minimum Shift Keyed (GMSK) modulation is one method of containing the spectral characteristics of the communication signals. However, this approach does not entirely solve the near-far interference problem.

Drawing Description Text (4):
FIG. 2 is a block diagram shows the operations to modulate and transmit a stream of binary-encoded information using the GMSK/M-ary spread-spectrum method;

Drawing Description Text (7):
FIG. 4 shows a preferred embodiment of GMSK modulation with 64-ary Gold-code sequences;

Drawing Description Text (9):
FIG. 6 shows the operations to synchronize and demodulate the received GMSK/M-ary spread-spectrum signal into binary information;

Drawing Description Text (10):
FIG. 7 shows a preferred embodiment of GMSK demodulation of 64-ary Gold-code sequences;

Detailed Description Text (3):
Referring to FIG. 2, a transmitter of the present invention includes an M-ary encoder 23, a spread spectrum encoder 25, a Gaussian minimum shift keying (GMSK) modulator 27, an up-converter 29 and a class-C transmitter 31.

Detailed Description Text (13):
Now referring to FIG. 4, the code sequences from the Gold code sequence 49 are pre-coded with a one-chip delay element 60 and an exclusive-OR 61. The output of the exclusive-OR 61 undergoes GMSK modulation. In particular, the output of the exclusive OR 61 is filtered by a low-pass filter 62 having an impulse response of ##EQU1##

Detailed Description Text (14):
where B is the bandwidth of the lowpass filter 62 having a Gaussian shape and T is the chip interval of the code sequence. The impulse response of the filter 62 is preferably a finite impulse response (FIR) clocked at a multiple of the chip rate. The filter output is integrated by an integrator 63 to yield modulation angles. In turn, a modulator 64 quadrature phase modulates an RF carrier based on the modulation angles.

Detailed Description Text (15):
The following discussion shows that the modulation pre-coding, 60 and 61, preserves the characteristics of code sequence after the GMSK modulation discussed above.

First, consider MSK modulation with a code sequence, p.sub.k, having values of .+-.1. The phase

Detailed Description Text (21):
If g(k) is passed through the modulation pre-coding of 60 and 61, the resulting sequence is

Detailed Description Text (24):
Now consider GMSK modulation. For GMSK, the pre-coded sequence p.sub.k is filtered with impulse response h(t), and truncated to finite length LT, to produce the modulation phase sequence ##EQU8##

Detailed Description Text (25):
The matched-filter correlation is with e.sup.-j.phi..sup..sub.k . Filtering the spreading sequence before modulation disperses each chip over a time interval greater than the chip duration of T. Consequently, correlating with a simpler signal such as s(kT) *, as defined for MSK, results in a correlation loss. However, the pre-coding, 61 and 62, preserves the Gold-code cross-correlation characteristics so that the correlation of the received signal with s(kT) * (see, Eqn. 6) is not significantly impaired by time offsets created by the filter 62.

Detailed Description Text (26):
The GMSK modulated carrier signal is then up-converted and transmitted by the transmitter, which is preferably a class-C transmitter 31, over a communication link. The communication link between the base station and its mobile radios is time-division multiple accessed (TDMA). The structure of TDMA, shown in FIG. 5, includes a continuous stream of frames 33. In turn, each frame includes a number of slots 35. More specifically, each 120-millisecond TDMA frame is divided into 72 time slots. In particular, the base station always transmits during three consecutive slots and every other three slots of the frame.

Detailed Description Text (31):
The receiver filter 70 rejects out-of-band noise and interference while passing the GMSK signal. The mixer 71 removes the (-j).sup.k sequence, or 90.degree./chip frequency offset produced by the MSK modulation. Further, the mixer 72 removes the g1 sequence, one of the two maximal-length sequences, during demodulation. The circular correlator 73 is therefore simplified to compute the correlation against the M-1 different shifts of a single maximal-length code sequence and the all-zero sequence.

Detailed Description Text (35):
In operation, the output signal from mixer 72, represented by I.sub.R +jQ.sub.R, is sampled an integer number of times per chip interval. The signal from the mixer 72 is preferably sampled twice per chip, or 126 times per GMSK symbol interval. As discussed above, the correlator 73 operates in two different modes: synchronization and demodulation. The correlator 73 operated in the synchronization mode to correctly align locally generated g1 and g2 code sequences to the received signal. After the locally generated code sequences are aligned in time to the received signal, the correlator 73 operates in the demodulation mode to find the most likely sequence of M-ary symbols that is being received.

Detailed Description Text (42):
The data processor 108 parses the digital messages, and either stores the received data for later transmission, outputs the data to the external interface, or uses the data for internal processing. During transmission, the data processor 108 outputs digital data messages to the radio. The radio encodes and interleaves the data for error correction prior to Gold-code encoding 10b and GMSK modulation 10c. The GMSK signal is then up-converted 10d to the RF carrier for amplification. The transmitter power is controlled by the data processor to assure link quality while minimizing interference to other networks. The amplified carrier is then conducted through the T-R switch 101 to be radiated by the antenna 100.

Detailed Description Text (49):
The g1-sequence generator 51 is initialized to a non-zero value, such as all-ones, during the unique-word and user-data intervals. The product of the g1 and g2

sequences is used to GMSK modulate the RF carrier for transmission. The preferred BT product is 0.25, thus confining 99.9% of the power of the modulated carrier to be within a bandwidth of less than 5 MHz. The BT product is the product of the Gaussian lowpass filter bandwidth, B, and the spreading-code chip interval, T, as defined earlier.

CLAIMS:

6. The transmitter according to claim 5 further comprising: a modulator configured to receive output from the filter and to apply minimum shift keyed modulation to the output of the filter.

36. The device according to claim 31 wherein the transmitter further comprises: a modulator configured to modulate a carrier signal based on the spread spectrum codeword sequence modulated using a Gaussian-filtered, minimum shift keying scheme.

44. The method according to claim 38 wherein the transmitter further comprises: modulating a carrier signal based on the spread spectrum codeword sequence modulated using a Gaussian-filtered, minimum shift keying scheme.

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L2: Entry 1 of 1 File: USPT Nov 14, 2000

DOCUMENT-IDENTIFIER: US 6148040 A
TITLE: Precoded gaussian minimum shift keying carrier tracking loop

Abstract Text (1):
An improved Gaussian minimum shift keying (GMSK) carrier tracking loop operating at baseband takes advantage of the orthogonality of precoded data GMSK signals and Laurent filtering to provide a carrier phase error signal generated at baseband for carrier phase derotation of the received GMSK signal. The carrier tracking loop also provides demodulated data estimates with performance equal to that of a GMSK serial demodulator. The tracking loop uses data directed feedback to improve noise rejection, but still has fast acquisition by operating at baseband.

Parent Case Text (2):
The present application is related to assignee's copending application entitled "Gaussian Minimum Shift Keying (GMSK) Precoding Communication Method" Ser. No.: 09/390,966, filed Sep. 07, 1999, by the inventors G. Lui and K. Tsai, and related to assignee's copending application entitled "Digital Timing Recovery Loop for GMSK Demodulators" Ser. No. 09/307,231, filed May 07, 1999, by the inventors T. Nguyen, J. Holmes, and S. Raghavan, both of which are here incorporated by reference as there fully set forth.

Brief Summary Text (2):
The invention relates to the field of continuous phase modulation communication systems. More particularly, the present invention is related to Gaussian minimum shift keying carrier tracking loops for use in combination with data preceding.

Brief Summary Text (4):
Communication systems have long transmitted digital signals using various carrier modulation techniques. The spectrum of a digital signal can be controlled and made compact by envelope filtering or phase domain filtering. An efficient phase domain filtering approach controls the signal spectrum by frequency modulating the filtered signal onto a carrier frequency to form a continuous phase modulated (CPM) signal. Because the CPM signal has a constant envelope, a power amplifier can be operated at maximum output power without affecting the spectrum of the filtered signal. Gaussian minimum shift keying (GMSK) is a form of continuous phase modulation. GMSK uses CPM signals with a constant signal envelope and a spectrum that can be made compact with the appropriate choice of the signal bandwidth bit time product (BT) product.

Brief Summary Text (5):
An M-ary GMSK signal is defined by its complex envelope described in terms of symbol energy E, symbol period T, carrier phase .theta..sub.c and phase modulation .theta.(t) using a modulation index h. Input data is formatted into data symbols prior to carrier modulation and transmission. The data formatting may be non-return to zero (NRZ) formatting. Equally probable NRZ data symbols belong to an M-ary alphabet of symbols having the symbol time T. The M-ary symbols are used to phase modulate a carrier reference. The GMSK phase response .theta.(t) originates from a Gaussian filter response g(t) of a Gaussian smoothing filter with a single sided 3 dB bandwidth B, truncated to an intersymbol interval duration L, that is a memory truncation length L. The GMSK Gaussian filter with a memory truncation length L of a GMSK signal is defined by the BT bandwidth bit time product, where B is the single sided 3 dB filter bandwidth in hertz. The Gaussian filter with a small BT product, has a memory length L equal to 1/BT. The Gaussian filter response g(t) used to phase modulate the carrier by a phase modulator having a modulation index h. In general, lowering the modulation index h while keeping the BT product constant will further reduce the spectral occupancy. The intersymbol memory length L is the number of

elapsed symbol periods for the GMSK signal to accrue a complete phase change amount due to a single input symbol and hence represents the memory of the GMSK signal. The phase modulated GMSK signal is transmitted to GMSK receiver for communicating the input data stream.

Brief Summary Text (9):
In the related application, Lui et. al., a data preceding algorithm is implemented prior to modulation in the transmitter to substantially improve the resulting BER performance of the continuous phase modulated (CPM) transmitters and receivers, such as the Gaussian minimum shift keying (GMSK) transmitters and receivers without the use of differential decoders while preserving the spectral occupancy the GMSK signals. The preceding algorithm encodes the source NRZ data symbols prior to the GMSK modulation so that the cumulative phase of the precoded symbols becomes the absolute phase of the data symbols in the signal phase trellis of the Viterbi algorithm. The preceding algorithm offers performance improvement for M-ary coherently demodulated GMSK signals.

Brief Summary Text (10):
Precoding improves the BER performance for coherent demodulation of the M-ary GMSK signals implemented using a pulse amplitude modulated signal subject to the Viterbi algorithm. The preceding algorithms encodes the source NRZ data symbols d.sub.n (t) prior to the GMSK modulation so that the cumulative phase of the precoded symbols d.sub.n (t) is identical to the exact phase of the source NRZ symbols at every stage of the Viterbi algorithm. In the Viterbi algorithm, the preceding process produces a set of survivor sequences for estimating the original data bit without the use of differential decoding. The Gaussian filter can be expressed mathematically, and the Laurent mathematical expansion dictates the matched filter bank. Without preceding, the Gaussian filter creates phase ambiguities that are resolved by differential decoding. Because the precoded symbols have the same statistics as the source symbols, the transmit spectrum of the GMSK signal is preserved while eliminating the need for differential decoding. Depending upon the channel bit error rate in operation, the precoding method will render a signal to noise ratio (SNR) improvement of 3 dB over the same modem that demodulates GMSK signals without preceding.

Brief Summary Text (12):
A reverse modulation method may be used in carrier phase tracking loops operating at high intermediate frequencies. The reverse modulation method works very well with differentially encoded data. However, when used with the precoded data, the tracking performance becomes unstable and sensitive to the loop gain. Additionally, when operating at high intermediate frequencies, more power is disadvantageously consumed. While prior GMSK systems have used preceding to avoid receiver differential decoding, the precoded data absolute phase characteristics have not been used for baseband operation of a carrier tracking loop. These and other disadvantages are solved or reduced using the invention.

Brief Summary Text (14):
An object of the invention is to provide carrier phase tracking using data precoded GMSK signals.

Brief Summary Text (17):
The present invention is directed to an improved GMSK carrier tracking loop operating at baseband while taking advantage of the orthogonality of precoded data GMSK signals and the absolute phase of the PAM filtered signals. As a precondition, the transmitted data sequence d(t) is precoded in the transmitter and communicated by Gaussian filtering and phase modulation of a carrier reference f.sub.c to provide a transmitted GMSK signal to a receiver. The GMSK carrier tracking loop carrier and phase demodulates the received GMSK signal R(t) into a baseband demodulated received R.sub.o (t) signal that is then separated into real inphase (I) and imaginary quadrature phase (Q) components both subjected to Laurent filtering to provide rough estimates of the baseband data signals of encoded data. Orthogonal switching and hard limiting is used to generate data A.sub.n and B.sub.n estimates, and of respective Q and I components at baseband. The A.sub.n and B.sub.n data estimates and .theta..sub.I and .theta..sub.Q phase error signals are cross-multiplied together for generating a phase error in closed loop carrier phase tracking at

baseband. These and other advantages will become more apparent from the following detailed description of the preferred embodiment.

Drawing Description Text (2):
FIG. 1 is a block diagram of a precoded GMSK communication system.

Drawing Description Text (3):
FIG. 2 is a block diagram of a precoded GMSK carrier tracking Loop.

Detailed Description Text (2):
An embodiment of the invention is described with reference to the figures using reference designations as shown in the figures. Referring to FIG. 1, a precode GMSK communication system includes a GMSK transmitter 10 and receiver 12 for communicating a GMSK signal S(t) from a transmitting antenna 14 to a receiver 16 antenna providing an intermediate frequency (IF) received signal R(t) received by a GMSK receiver 12. The GMSK signal S(t) is subjected to noise and interference, both not shown, during communication of the signal. The transmitter 10 includes a data source 18 that may be a non-return to zero (NRZ) formatted data source providing a data stream d(t) to a data precoder 20 providing in turn a sequence of precoded symbols a(t) where a(t) is defined as a.sub.n (t)=d.sub.n-1 (t)d.sub.n (-1).sup.n having bit duration of T for the nth bit with a bit rate of R.sub.b. The precoded symbols a(t) are communicated to a modulator 22 that includes a Gaussian filter 24 having a predetermined bandwidth bit-time product BT.sub.b. The Gaussian filter 24 receives the encoded symbols a(t) as +/-1 volt pulses to generate respective Gaussian filter pulse responses g(t) overlapped by memory length L and communicated to an integrator 26 providing an accumulative Gaussian filter response signal G(t) that is in turn communicated to a phase modulator 28 that phase modulates a f.sub.c carrier reference 30 by the accumulative Gaussian filter response signal G(t) to provide the GMSK signal S(t). Gaussian filter responses g(t) for the symbols a(t) are superimposed over the time period of the memory truncation length L and communicated to the integrator 26 when generating a complete Gaussian filter response G(t) communicated to the phase modulator 28 providing the GMSK signal S(t) as a continuous phase modulated (CPM) signal. The phase modulator 28 is defined by a modulation index h. The respective Gaussian pulse responses g(t) of the Gaussian filter 24 is a function of the BT product and the truncation memory length L. The phase modulation .phi.(t) is equal to the .pi.hG(t). The accumulative Gaussian filtered response G(t) is phase modulated by the phase modulator 28 to generate the CPM GMSK signal S(t) having a constant envelope. The receiver 12 receives the transmitted GMSK signal S(t) as the received signal R.sub.c (t) is a function of the transmitted signal and a noise component.

Detailed Description Text (3):
The function of the receiver 10 is to generate an estimate d(t) of the original data stream d(t). The receiver 12 including a demodulator 32 receives the received signal R(t) for generating a baseband signal R.sub.o (t) for data recovery. The received signal R(t) is also communicated to a GMSK carrier phase acquisition loop 34 providing a carrier phase estimate .theta..sub.c, to a GMSK carrier frequency acquisition providing a carrier frequency estimate f.sub.c, and to a GMSK timing acquisition loop 38 providing an initial tracking timing signal .tau..sub.o. A data detector 40 generates the estimated data d(t) communicated to a data sink 42. The data detector 40 receives the received baseband signal R.sub.o (t) from a precoded GMSK carrier tracking loop 44 and a data timing .tau.(t) signal from a GMSK timing recovery loop 46 preferably including a digital tracking transition loop 48 and a hard limiter 50. The digital tracking transition loop 48 provides the data timing signal .tau.(t) to the data detector 40 for recovery data estimation. The data timing signal .tau.(t) is received by the hard limiter 50 providing a hard clocking signal C.sub.H (t) to the digital tracking transition loop 48 in closed loop control for rapidly stabilizing the data signal .tau.(t) at baseband for clocking the data detector 40. The data detector 40 is preferably a trellis receiver having Viterbi decoding and Laurent matched filtering. The data detector 40 preferably includes a Laurent filtering, data sampling and Viterbi decoding for providing the data estimate d(t). The received baseband signal R.sub.o (t) is a representation of the output of the integrator 26. The timing recovery loop 46 in combination with the data detector 40 is an inverse function of the data precoder 20, Gaussian filter 24 and integrator 26, to provide the estimated data d(t). Loops 34, 36 and 38 may be of

conventional designs. The invention is directed to the precoded GMSK carrier tracking loop 44 shown in detail in FIG. 2.

Detailed Description Text (4):
Referring to FIGS. 1 and 2, and more particularly to FIG. 2, the improved precoded GMSK carrier tracking loop 44 receives the carrier frequency estimate f.sub.c and carrier phase estimate .theta..sub.c to provide a carrier demodulated and phase adjusted baseband received signal R.sub.o (t). The carrier signal f.sub.c is received by a carrier receiver 52 to provide a carrier demodulation signal to a carrier demodulator 54 that demodulates the received signal R(t) into a carrier demodulated baseband received signal R.sub.c (t) that is then communicated to a phase demodulator 56 that removes the carrier phase .theta..sub.c and a phase error .theta..sub.e from a phase receiver 58 to then provide the carrier and phase demodulated baseband received signal R.sub.o (t). The demodulated baseband received signal R.sub.o (t) is a function of the received signal R(t) that can expressed as a complex baseband signal. ##EQU1##

Detailed Description Text (5):
The demodulated baseband received signal R.sub.o (t) is received by a complex to real and imaginary converter 60 to provide a real inphase Q component and an imaginary quadrature I component respectively communicated to a fundamental PAM real inphase filter h.sub.0 (t) 62 and to a fundamental PAM imaginary quadrature filter h.sub.0 (t) 64 to respectively provide a .theta..sub.I PAM filtered signal and a .theta..sub.Q PAM filtered signal. The .theta..sub.I and .theta..sub.Q PAM filtered signals from the PAM filters 62 and 64 are baseband signals having time varying positive and negative phase values corresponding to positive and negative pulses of the input data precoded sequence a(t). ##EQU2##

Detailed Description Text (6):
The .theta..sub.I PAM filter signal from the PAM real filter 62 is communicated to a 2kT sample and hold switch 66 providing an even sampled phase .theta..sub.AI and communicated to a (2k+1)T sample and hold switch 68 providing an odd sampled phase .theta..sub.AQ that is communicated connected to an I hard limiter 70. The I hard limiter 70 provides zero and one hard limited estimated data A.sub.n representing the odd sampled phase .theta..sub.AQ from the sampled and held switch 68 sampling at odd sample times (2k+1)T. The inphase filtered signal .theta..sub.I is sampled and held by switch 68 at the beginning of the odd sample times for one bit period T. That is, the sampling switch 66 provides the even sample phase .theta..sub.AI by sampling the real PAM filtered signal .theta..sub.I at the beginning of even sample times 2kT and holding the sampled value for one bit duration T. The .theta..sub.Q PAM filtered signal from the Imaginary PAM filter 64 is communicated to a 2kT sample and hold switch 72 providing a Q even sampled phase .theta..sub.BI and to a (2k+1)T sample and hold switch 74 providing a Q odd sampled phase .theta..sub.BQ that is then communicated to a Q hard limiter 76. The .theta..sub.BI sampled phase output from the sampling switch 72 is fed into a Q hard limiter 76 for providing a hard limited estimated data B.sub.n. The estimated data sequences B.sub.n and A.sub.n are estimated data of the precoded sequences because the absolute phase of the phase of real and imaginary PAM filter signals .theta..sub.I and .theta..sub.Q correspond to the precoded data sequence a(t) at symbol boundaries.

Detailed Description Text (7):
Sampling switches 66 and 72 operate in synchronism clocking at 2kT even symbol boundaries, whereas sampling switches 68 and 74 operate in synchronism clocking at (2k+1)T odd symbol boundaries. The term k is an incrementing integer index for consecutive symbol boundary times. The switches 66, 68, 72 and 74 are switched at multiples of T, the symbol time period, when the outputs of 66, 68, 72 and 74 are held through the symbol time T. Switches 66 and 72 synchronously respectively sample Q and I PAM filtered outputs .theta..sub.Q and .theta..sub.I at times 2kT, and switches 68 and 74 sample Q and I PAM filtered outputs .theta..sub.Q and .theta..sub.I at times (2k+1)T. The output of the sampling switches 66, 68, 72 and 74 provide sampled phase values that are positive and negative and between +1 and -1 indicating a phase rotation and therefore indicating binary values of data bits of the precoded sequence a(t).

Detailed Description Text (13):

The GMSK signal starts at a zero phase for the first precoded symbol. Thereafter, the phase modulation is continuous and varies between +/-.pi./2. The hard limiters 70 and 76 provide respective data symbol estimates A.sub.n and B.sub.n at the symbol time T, and hence functions as first order data detectors through a defined relationship between the phase errors and the estimated data.

Detailed Description Text (17):
The precoder 20 precodes the input data d(t) so that the signal magnitude of the filtered signals represent the input data d(t) at the odd and even sample times. Hence, the Data is present during odd and even samples, and can be sampled for improved phase demodulation. The data B.sub.n and A.sub.n sampled by switches 68 and 72 and hard limited by limiters 70 and 76 and the phases .theta..sub.BQ and .theta..sub.AI sampled by the switches 66 and 74 are then used by multipliers 80 and 78 and summer 82 to generate the phase error signal .epsilon..sub.n. The error signal .epsilon..sub.n is in the form of a phase error. ##EQU3##

Detailed Description Text (18):
The present invention is directed to a Laurent filtering GMSK carrier tracking loop operating at baseband for demodulating a received GMSK signal communicating precoded data, into a demodulated baseband received signal. No squaring of the received signal is required. The invention is characterized by separating the demodulating baseband receive signal into real and imaginary components both subjected to Laurent filtering to provide baseband soft data signals of encoded data subject to orthogonal switching and hard limiting to generate phase error signals at baseband for closed loop carrier phase tracking. The carrier tracking loop does provide estimates of the data sequence and could be modified to provide data estimates as part of data detection. Those skilled in the art can make enhancements, improvements, and modifications to the invention, and these enhancements, improvements, and modifications may nonetheless fall within the spirit and scope of the following claims.

CLAIMS:

1. A method of demodulating a received signal having a phase modulated carrier signal of a carrier signal modulated by symbols having a symbol time period, the symbols are generated from preceding an input data stream as a precoded input data stream, the method comprising the steps of,

carrier demodulating the received signal by a carrier reference into a carrier demodulated signal,

phase demodulating the carrier demodulated signal by a phase amount into a baseband received signal,

converting the baseband received signal into an imaginary component and a real component,

real filtering the real component into a real phase signal,

imaginary filtering the imaginary component into an imaginary phase signal,

even real sampling at even symbol time boundaries the real phase signal into a sampled even real phase signal,

odd real sampling at odd symbol time boundaries the real phase signal into a sampled odd real phase signal,

real hard limiting the sampled odd real phase signal into real data estimates,

even imaginary sampling at even symbol time boundaries the imaginary phase signal into a sampled even imaginary phase signal,

odd imaginary sampling at odd symbol time boundaries the imaginary phase signal into a sampled odd imaginary phase signal,

imaginary hard limiting the sampled even imaginary phase signal into imaginary data estimates, the imaginary and real data estimates are alternating estimates of the input data stream,

even phase multiplying the imaginary data estimates by the sampled even real phase signal for generating an even phase error,

odd phase multiplying the real data estimates by the sampled odd imaginary phase signal for generating an odd phase error,

combining the even and odd phase errors into a phase error estimate, and

phase adjusting the phase amount by the phase error estimate for phase demodulation of the carrier demodulated signal during the phase demodulating step.

2. The method of claim 1 wherein,

the precoded input data stream is Gaussian filtered to provide the received signal having a pulse amplitude modulation representation of the Gaussian filtering,

the real and imaginary filtering steps are matched filtering steps that are matched by the pulse amplitude modulation representation to the Gaussian filtering, and

the real and imaginary phase signals are filtered signals having an absolute phase at a periodic sampling time for indicating the data of the input data stream.

3. The method of claim 1 wherein,

the precoded input data stream is Gaussian filtered to provide the received signal having a pulse amplitude modulation representation of the Gaussian filtering,

the real and imaginary filtering steps are matched filtering steps that are matched by the pulse amplitude modulation representation to the Gaussian filtering,

the real and imaginary phase signals are filtered signals having an absolute phase at a periodic sampling time for indicating the data of the input data stream, and

the matched filtering steps apply a principal Laurent function to the baseband signal so that the real and imaginary filtered signal comprises a Laurent component.

8. A method of generating an output data stream from a received signal having a phase modulated carrier signal of a carrier signal modulated by precoded symbols having a symbol time period, the symbols are generated from preceding an input data stream as a precoded input data stream, the method comprising the steps of,

generating a carrier reference estimate from the received signal,

generating a carrier phase estimate from the received signal,

carrier demodulating the received signal by the carrier reference estimate into a carrier demodulated signal,

phase demodulating the carrier demodulated signal by a phase amount into a baseband received signal,

converting the baseband received signal into an imaginary component and a real component,

real filtering the real component into a real phase signal,

imaginary filtering the imaginary component into an imaginary phase signal,

even real sampling at even symbol time boundaries the real phase signal into a sampled even real phase signal,

odd real sampling at odd symbol time boundaries the real phase signal into a sampled odd real phase signal,

real hard limiting the sampled odd real phase signal into real data estimates,

even imaginary sampling at even symbol time boundaries the imaginary phase signal into a sampled even imaginary phase signal,

odd imaginary sampling at odd symbol time boundaries the imaginary phase signal into a sampled odd imaginary phase signal,

imaginary hard limiting the sampled even imaginary phase signal into imaginary data estimates, the imaginary and real data estimates are alternating estimates of the input data stream,

even phase multiplying the imaginary data estimates by the sampled even real phase signal for generating an even phase error,

odd phase multiplying the real data estimates by the sampled odd imaginary phase signal for generating an odd phase error,

combining the even and odd phase errors into a phase error estimate,

phase adjusting the phase amount by the phase error estimate for phase demodulation of the carrier demodulated signal during the phase demodulating step by adjusting the carrier phase estimate by the phase error estimate for determining the phase amount, and

data detecting the baseband received signal into the output data stream being an estimate of the input data stream.

9. The method of claim 8 wherein,

the precoded input data stream is Gaussian filtered to provide the received signal having a pulse amplitude modulation representation of the Gaussian filtering,

the real and imaginary filtering steps are matched filtering steps that are matched by the pulse amplitude modulation representation to the Gaussian filtering, and

the real and imaginary phase signals are filtered signals having an absolute phase at a periodic sampling time for indicating the data of the input data stream.

10. The method of claim 8 wherein,

the precoded input data stream is Gaussian filtered to provide the received signal having a pulse amplitude modulation representation of the Gaussian filtering,

the real and imaginary filtering steps are matched filtering steps that are matched by the pulse amplitude modulation representation to the Gaussian filtering, and

the real and imaginary phase signals are filtered signals having an absolute phase at a periodic sampling time for indicating the data of the input data stream, and

the matched filtering steps apply a principal Laurent function to the baseband signal so that the real and imaginary filtered signal comprises a Laurent component.

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L11: Entry 6 of 9 File: USPT Jan 17, 1984

DOCUMENT-IDENTIFIER: US 4426710 A
TITLE: Processes for generating duo-binary FSK, tamed FSK and TFM modulations and modulators applying those processes

Abstract Text (1):
To obtain a duo-binary FSK modulation, the modulating binary signal train has a three state partial response and is fed through a precoding, a transition-type coding, a simplified MSK modulation at the carrier frequency, a frequency division by two, and a multiplication by the same signal delayed by one binary element period. In order to obtain a "tamed FSK" modulation, the modulating binary signal train has a five state partial response and is fed through precoding, a transition-type coding, a simplified MSK modulation at the carrier frequency, a frequency division by two, a multiplication by the same signal delayed, for one part, by one binary element period and, for the other part, by two binary element periods. A TFM modulation is obtained by using the FSK duo-binary generating process, but a wave shaping filter is connected between the division by two circuit and the multiplication circuit. In a TFM modulator, the train of binary signals is applied to a partial response precoding circuit, the output of which is connected to a transition-type coding circuit, the output of which is connected to the input of a simplified MSK modulator, the output of which is connected to the input of a frequency divider by two, the output of which is connected to the input of a wave shaping filter, the output of which is directly connected to an input of a multiplier, and to the other input of the multiplier via a delay-type circuit.

Brief Summary Text (5):
According to a characteristic of the present invention, a process generates a duo-binary FSK modulation, in which a partial response precoding, with three states, is applied to the train of modulating binary signals. Then, there is a coding by transition, followed by a simplified MSK modulation at the carrier frequency, a division by two of the frequency, and then a multiplication by the same signal delayed by one binary element period.

Brief Summary Text (6):
According to another characteristic, a process for the generation of a "tamed FSK" modulation applies to the train of modulating binary signals, a partial response precoding with five states, then a coding by transition, then a simplified MSK modulation at the carrier frequency, then a division by two of the frequency, then a multiplication by the same signal delayed, for one part by a binary element period and, for the other part, by two binary element periods.

Brief Summary Text (9):
According to another characteristic, a modulator applies the train of modulating binary signals to a partial response precoding circuit, the output of which is connected by a coding by transition circuit, the output of which is connected to the input of a simplified MSK modulator, the output of which is connected to the input of a frequency divider by two, the output of which is connected, for one part, directly to the input of a multiplier and, for the other part, to the other input of the multiplier via a delay-type circuit T.sub.2, in which T is the period of the train of binary elements.

Detailed Description Text (10):
a precoding which transforms an .alpha..sub.1 binary train into a d.sub.i binary train through the module 2 relationship:

Detailed Description Text (16):

The known diagram showing the principle of a partial response frequency modulator with 3 states with a 1/2 frequency index is shown in FIG. 1. In that diagram, the binary pure signals .alpha..sub.n are applied to a precoding circuit 1 which delivers the d.sub.n signals and the output of which is connected to the input of a filter 2, the output of which is connected to a modulator 3 which delivers the signal y.sub.3,n. The precoding circuit 1 comprises an exclusive-OR gate 4, one input of which is connected to the input of 1 and the output of circuit which is connected, for one part to the output of circuit 1 and, for the other part, to the input of a delay-type circuit T 5, the output of which is connected to the second input of the exclusive-OR gate 4. The precoding circuit performs the addition (modulo 2) indicated above in formula (3). Filter 2 has a complex gain F.sub.3 (.nu.):

Detailed Description Text (20):
As a precedent, the modulation has a 1/2 index where .DELTA.F=1/2T. The known diagram of principle of a corresponding modulator is the one given in FIG. 2 which still comprises a precoding circuit 6, the input of which receives the pure binary signal .alpha..sub.n and the output of which is connected to the input of a filter 7. The output of filter 7 is connected to the input of a modulator 8, the index frequency of which is 1/2, which delivers y.sub.5,5 (t). Precoding circuit 6 comprises a first exclusive OR gate 9, one input of which is connected to the input of precoding circuit 6 and the output of which is connected, for one part, to its second input through a delay-type circuit T 10 and, for the other, to the first input of a second exclusive OR gate 11. The output of the exclusive OR gate 11 is connected, for one part, to its second input through a delay-type circuit T 12 and, for the other part, to the output of circuit 6. Thus, precoding circuit 6 executes the above-indicated operation in formula (6). Filter 7 has a complex gain F.sub.5 (.nu.) such that:

Detailed Description Text (33):
In the modulator in FIG. 4, the pure binary signals .alpha..sub.n are applied to the input of a precoding circuit 20, the output of which is connected to the input of a transition-type coding circuit 21, the output of which is connected to the input of a simplified MSK modulator 22 the output of which is connected to the input of a divider by two 23. The output of the divider by two 23 is connected, for one part directly, to the first input of a multiplier 24 and, for the other part, through a delay-type circuit 25, to the second input of multiplier device 24. The output of multiplier device 24 is connected to the input of a band filter 26.

Detailed Description Text (34):
Precoding circuit 20 is identical to the precoding circuit 1 in FIG. 1. That is why the components of circuit 20 have the same numerical references as the components of circuit 1. Transition-type coding circuit 21 also comprises an exclusive OR gate 27, the output of which is connected, through a delay-type circuit 28, to one of its inputs. The simplified MSK modulator 22 is identical with the one in FIG. 3. That is why the same numerical references are used to designate the circuits which compose it.

Detailed Description Text (41):
In the modulator in FIG. 5, the signals .alpha..sub.n are applied to the input of a precoding circuit 29, the output of which is connected to the input of a transition-type coding circuit 30, the output of which is connected to the input of a simplified MSK modulator 31, the output of which is connected to the input of a divider by two 32. The output of divider by two 32 is connected for one part to the input of another divider by two 33 and, for the other part, through a delay-type circuit T 34, to the first input of a multiplier 35. The output of divider by two 33 is connected, for one part directly to the second input of multiplier 35 and, for the other part, through a delay-type circuit 2T 36, to the third input of multiplier 35. The output of multiplier 35 is connected to the input of a band filter 37 which delivers the modulated signal.

Detailed Description Text (42):
Precoding circuit 29 is identical with precoding circuit 6 in FIG. 2. Circuit 30 is identical with circuit 21 in FIG. 5. The simplified MSK modulator 31 is identical with that in FIG. 3, that is why the same numerical references are used to designate

the circuits which compose it. Dividers by two 33 and 32 prepare the terms of the expression (18) above. Multiplier 35, which may be decomposed into two ring-shaped multipliers, performs the multiplications necessary to obtain the phase additions of expression (18). Band filter 37 is centered on the central frequency f.sub.c =(f.sub.1 +f.sub.2)/2 and it has as its effect to eliminate harmonics.

Current US Cross Reference Classification (2):
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Current US Cross Reference Classification (3):
375/305

CLAIMS:

1. A process for generating a duo-binary FSK modulation comprising the steps of: first applying to a modulating binary signal train a 3- state partial response precoding, second applying to the precoded signal a coding by transition, third applying to the resulting transition coded signal a simplified MSK modulation at the carrier frequency, fourth dividing by two the modulated signal of the first step, and fifth applying to the modulated signal divided by two, a multiplication by the same modulated signal with a divided frequency delayed by one period of binary element.

2. A process for generating a "tamed FSK" modulation, comprising the steps of: first applying to a modulating binary signal train a 3-state partial response precoding, second applying to the precoded signal a transition-type coding, third applying to the resulting transition coded signal a simplified MSK modulation at the carrier frequency, fourth dividing by two the signal modulated in the third step and fifth applying to the modulated signal divided by two a multiplication by the modulated signal with a frequency divided by two and delayed for one part by one period of a binary element and, for the other part, by two periods of said binary elements.

4. A modulator which utilizes the process according to claim 1, said modulating comprising precoding circuit means, a transition-type coding circuit means, MSK modulator means, divide by two means, multiplier means, and delay-type circuit means, in which the modulating binary signal train is applied with partial response to said precoding circuit means, an output of which is connected to said transition-type coding circuit means, applying an output of said transition-type coding circuit means to the input of said simplified MSK modulator means, an output of said MSK modulator means being connected to the input of said means for dividing the frequency by two, an output of said divide by two means being connected for one part directly to the input of said multiplier means and, for the other part, to the other input of said multiplier means via said delay-type circuit means, in which the delay is equal to the period of the train of binary elements.

L11: Entry 2 of 9 File: USPT Feb 6, 2001

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**** See image for Certificate of Correction ****
TITLE: Transmitter/receiver for GMSK and offset-QAM

Brief Summary Text (19):
In accordance with one aspect of the present invention, an inventive transmitter encodes a number 2N (e.g., 2N=4) data bits by using N (e.g., two) data bits to select one of two to the power N (e.g., four) levels of a cosine wave and the other N data bits to select one of two to the power N levels of a sine wave. In contrast to prior art 16QAM, the inventive modulation attains the cosine wave levels at instants between the instants that the sine wave attains its modulation levels, that is, at instants offset by half a 2N-bit (e.g., 4-bit) symbol interval, the modulation thus being known as Offset QAM or OQAM. A receiver according to the invention receives the OQAM signal and amplifies, filters and digitizes the received signal at a sampling rate of preferably only two samples per 2N-bit symbol interval (i.e., one sample per N-bit half-symbol interval). Successive N-bit half-symbols comprise information modulated alternately on a cosine and a sine carrier wave, that is, successive half-symbols are rotated by 90 degrees. In one embodiment of the inventive modulation, this rotation successively has the values 0,90,0,90,0,90 . . . and so on, while in an alternative embodiment of the inventive modulation, the successive rotation takes on the values 0,90,180,270,0,90,180,270 . . . and so on, such that successive cosine wave symbols are alternately inverted (0,180,0,180 . . .) while successive sine wave symbols are likewise alternately inverted (90,270,90,270 . . .). This alternate inversion of successive cosine and successive sine wave symbols does not change the modulation in principle, and merely requires that the successive inversion be corrected by inverting alternate cosine and sine symbols either before modulation (by use of precoding), or alternatively, after demodulation.

Detailed Description Text (5):
GSMK signals may alternatively be either differentially or coherently modulated. In the case of differential modulation, each successive information bit initiates either a +90 or a -90 degree signal phase rotation relative to the previous phase. In the alternative case of coherent modulation, the final signal phase after completing a +90 or a -90 degree rotation is directly indicative of a data bit polarity. As is well known from the GSM system, coherent GMSK may be produced by a differential GMSK modulator using suitable precoding of the applied information bitstream. Coherent GMSK provides superior performance and is a preferred, although not essential, form of GMSK herein.

Current US Cross Reference Classification (3):
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